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PATENT SPECIFICATION

624.179



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COMPLETE SPECIFICATION

Improvements in or relating to Electro-Mechanical Power Transmission Systems

- We, EMILE HYACINTHE DESMOULINS, of 37, Quai, National, Puteaux, Seine, France, and MAURICE THIRIET, of 38, rue Campo Formio, Paris, 13e, Seine, France, both French Citizens, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—
- 10 The present invention relates to electro-mechanical power transmission systems for the propulsion of vehicles.
- In one known type of system the vehicles have been provided with a power unit comprising a heat engine such as a Diesel engine, coupled to an electric generator. The propulsion has been obtained from electric motors supplied with electrical energy generated in said generator. The regulation of the speed of the vehicle is derived by varying the excitation current of the generator by means such as variable resistor included in the field circuit of the generator.
- 25 In an installation of this type there is, therefore, a generator of sufficient power to absorb all the energy which the heat engine can develop, and electric motors of a sufficient total power to absorb all the electrical energy generated in the generator. Thus, allowing for energy losses, the electrical equipment installed on the vehicle has a total power capacity equal to twice the total power developed by the heat engine. This arrangement has numerous disadvantages, such as weight and cumbrousness.
- It has been proposed to drive one element of a differential by the prime mover, and to connect another element to a dynamo-electric machine which is connected electrically to a second dynamo-electric machine driven by the prime mover. By adjustment of the magnitude and directions of the field excitation currents in the two dynamo-electric machines the resulting motion of the third element of the differential may be controlled as required. The third element of the differential is transmitted to the propulsion wheels of a vehicle in any suitable known manner.
- In such an apparatus, half at least of the approximate output of energy developed by the prime mover is transmitted mechanically to the propelling devices of the vehicle and the other half undergoes a temporary transformation into electric energy which is used in the production of a motor torque of variable direction and value which, adding itself algebraically to that part of the energy not electrically transformed, and transmitted to the propulsive devices, allows varying mechanical energy to be received by these propulsive devices of the vehicle, from zero to the total maximum energy which can be developed by the prime mover of the unit, of course, after allowing for losses of energy in the latter.
- Thus, there is brought about a reduction of the total power of the electrical equipment of the unit to a value which may be less than the power of the driving engine of the unit, thereby effecting a lightening of the unit, a simplification of the unit, an increase of its output, a reduction of its maintenance, a reduction of its cumbrousness and many other advantages.
- It has also been suggested in Specification No. 21173 of 1903 that the field in the dynamo-electric machines may be obtained from series windings, from shunt windings or by combining several different windings.
- According to the present invention a power unit for driving the driving shaft of a vehicle in which one element of a differential is driven mechanically by a prime mover, a second element of the differential is connected to a first dynamo-electric machine electrically connected to a second dynamo-electric machine driven by said prime mover, and the resulting

motion of a third element of said differential is transmitted to the driving shaft is characterised by the provision of a series field excitation winding for each machine, 5 said windings forming part of the electrical connection between said machines, a separate field excitation winding for each of said machines, a common source of electrical energy connected to said 10 separate field windings, means to adjust the magnitude of current in the separate field winding of said first machine, and means to adjust the magnitude and to determine the direction of current in the 15 separate field of said second machine.

Preferably there is provided means for interrupting current flowing between said machines and in said separate field windings and means for locking all the elements of said differential. 20

Preferably the prime mover is connected to one sun wheel of the differential, the first dynamo-electric machine is connected to a second sun wheel, and the 25 resulting motion of a planetary element is transmitted to the driving shaft of the vehicle.

In this power unit the common source of electrical energy can be equally well 30 provided by a dynamo or by a battery of accumulators.

The locking together of all the elements of the differential gear can be obtained by any suitable means, for example with the 35 aid of a temporary coupling device from one of the machines with the satellite wheels of the differential gear, or else by a temporary coupling device for the two planetary wheels of the differential gear.

The present invention will be described with reference to the accompanying drawings which are for example only and do not in any way limit the scope of the present invention. In the drawings:— 40

Fig. 1 shows diagrammatically a power unit of known type having a heat engine as prime mover for driving the vehicle.

Fig. 2 shows diagrammatically a power unit according to the present invention for 50 driving the driving shaft of a vehicle.

Fig. 3 shows diagrammatically a power unit according to the present invention including means for locking all the elements of the differential and means for 55 interrupting the flow of current in the electrical part of the unit.

In Fig. 1 the power unit represented comprises a heat engine M (a Diesel engine for example) of which the shaft 60 drives a generator G and a coaxial generator E. This latter generator E feeds separate field excitation winding through a rheostat R_h. The generator G supplies current in its turn through conductors 65 C₁, C₂, to two motors m mounted on the

axles e—e of the vehicle to be propelled.

As previously stated, in an installation of this type, the electric power of the twin machine unit is, allowing for losses of 70 energy, equal to that of the generator G which is itself, allowing for losses of energy, equal to that of the heat engine M, so that the unit of the electrical equipment installed on board the vehicle, is, 75 always allowing for energy losses in the plant, equal to twice the power of the heat engine M.

In Fig. 2 the power unit represented comprises:—

(1°) The heat engine 1 as prime mover, 80 for example a Diesel engine, of power P_M

(2°) Coupled on the shaft of this engine

(a) On the part 2^m of the shaft, adjoining the engine 1 a dynamo-electric 85 machine 3^a of a maximum power equal at least to half the power of the engine 1.

(b) On the opposite part 4 of this shaft a generator 5.

(c) On the prolongation 6^a of this shaft, 90 situated beyond the machine 3^a a sun wheel 7 of a differential gear.

(3°) The other elements of this differential gear namely

(a) The second sun wheel 8 mounted on 95 a shaft 6^b, this shaft 6^b being rigidly connected to a dynamo-electric machine 3^b of a maximum power equal to at least half of the power of the engine 1.

(b) The planet wheels 9 arranged 100 between the two sun wheels, 7, 8.

(c) The planet wheel carrier 10^a.

(4°) A mechanism of any known type for transmission of the power received by the planet wheel carrier 10^a to the 105 driving device of the vehicle.

(5°) Means associated with these two electric machines 3^a and 3^b these means comprising

(a) An electric connection of the arma- 110 tures of these two motors by means of conductors 12 and 13 of which the one 12 includes a series field winding 14^a in series with the armature of the machine 3^a and a series field winding 14^b in series 115 with the armature of the machine 3^b.

(b) Separate field windings 15^a and 15^b for independent excitation of these two machines 3^a and 3^b by means of the common generator 5. 120

(c) A potentiometric rheostat 16 in circuit with winding 15^a for the excitation of the machine 3^a, this rheostat allowing of varying the excitation of this machine from its full positive value to its full 125 negative value, passing through the zero value of excitation.

(d) An ordinary rheostat 17 connected in the excitation circuit of the machine 3^b. 130

The mechanism of power transmission received by the planet wheel carrier 10^d to the driving device 11 of the vehicle, here assumed to be a Diesel electric locomotive, comprises:—

(1st) For the forward drive of the vehicle a first gear 18 fixed to the planet wheel carrier 10^d and in engagement with a gear wheel 19 free on the shaft 11.

(2nd) For the reverse drive a second gear 20, also fixed to the planet wheel carrier 10^d, this gear being in engagement with a pinion 21 with axle 22 itself in engagement with a gear wheel 23 loose on shaft 11.

(3rd) A clutch plate 24 movable axially along shaft 11 between the two gear wheels 19 and 23 but keyed to this shaft. This plate is driven in any known manner and provided, as well as the wheels 19 and 23, with any appropriate (mechanical, electric or other) clutch means 25, 26 and 27, carried, the one by plate 24, the other by the wheels 19, 23.

The shaft 11 is terminated by bevel pinions 28 in engagement with bevel wheels 29 mounted on the axles 30 of the Diesel electric locomotive to which the preceding power unit belongs.

The whole is thus driven relatively to this unit.

Assuming C_m to represent that part of the torque of the heat engine which is transmitted to shaft 2m.

C_a to represent the torque transmitted to the shaft 6^a by the machine 3^a.

C_b to represent the torque transmitted to shaft 6^b by the machine 3^b.

and C_d to represent the torque transmitted to the gear train by the satellite carrier 10^d, and allowing that these torques are positive when they are exerted in the direction of rotation of the heat engine M and negative when they are exerted in the reverse direction, the above symbolised torques are approximately connected amongst themselves by the following relations

$$\begin{aligned} C_m + C_a + C_b &= C_d \\ C_m + C_a &= C_b \end{aligned}$$

Designating by

V_{ma} , the speed of the driving engine of the plant and of the motor 3^a

by V_b , the speed of the motor 3^b

and by V_d , the speed of the satellite carrier 10^d and by assuming that these are positive in the direction of rotation of the engine 1 and negative in the opposite direction the system answers also to the following law

$$V_d = \frac{V_{ma} + V_b}{2}$$

Finally starting with

P_m representing the power furnished by the engine 1

P_a representing the power furnished by the machine 3^a

P_b representing the power furnished by the machine 3^b

P_d representing the power furnished by the satellite carrier 10^d

and agreeing that these powers are positive where they are in the same sense as that of the engine 1 and negative in the opposite sense the system responds approximately to the law

$$P_m + P_a + P_b = P_d.$$

OPERATION.

The heat engine 1 being put into operation by the usual methods, and the vehicle being stopped the machine 3^a will evidently turn at the same speed and in the same direction as the engine 1. Therefore if the two machines are fully excited and suitably connected, so that their voltages are equal and opposed, there is no exchange of current between them. If now the excitation of machine 3^a is reduced a circulating current is produced between the two machines, the machine 3^b becomes a generator, the machine 3^a becomes a motor, and the two torques C_a and C_b are equal and both positive. The engine 1 only transmits the power necessary to compensate the losses. The torque exercised by the planet wheel carrier 10^d on the gear train is therefore

$$C_d = C_a + C_b$$

This torque depends on the current circulating in the conductors 12 and 13. It is equal to the normal torque C_m of the Diesel engine operating at normal power P_m when the intensity attains the value I

corresponding to the power $\frac{P_m}{2}$ of each of the machines 3^a and 3^b when fully operating.

The vehicle can therefore commence to move with full torque.

If the reduction in the excitation of the machine 3^a is continued, the speed of the vehicle accelerates. The torque C_b remains constant so long as the current I in the connections 12 and 13 is kept constant, the torque C_a diminishes, and as a result the torque C_m increases so that at each instant

$$C_m + C_a = C_b$$

When the excitation of the machine 3^a becomes zero the machine 3^b is practically stopped and the speed of the planet wheel carrier is equal to

$$V_d = \frac{V_m}{2}$$

Its torque has remained the same since

I (armature) and I_a (excitation) have not varied but the torque of the machine 3^a has become zero, from which $C_m = C_b$.

The engine 1 has therefore alone to furnish at this instant the mechanical power to the wheels, there is no longer, except for losses, transformation of electric power into mechanical power.

The acceleration of the vehicle is pursued by reversing the direction of the excitation current, I_a of the machine 3^a and increasing progressively the excitation of this machine in the new direction. The machine 3^a is then a generator, and the machine 3^b remains a motor. The effect at the rims of the wheels continues to remain constant keeping I , I_a or I_b (excitation) constant when the machine 3^a has arrived at fully reversed field

$V_m = V_b$ therefore $V_d = V_{m_a} = V_b$ at this speed the torques C_a and C_b being equal and in contrary directions
 $C_m = 2C_a$

and as a result

$$P_m = 2P_a \text{ or } P_a = \frac{P_m}{2}$$

Half of the power of the engine 1 alone is transferred into electrical energy the other part is directly transmitted to the gear train.

All the elements of the differential gear form a block and the output of the differential gear is therefore 100%. The transformations of electrical energy into mechanical energy can then be stopped and the output improved by locking together all the elements of the differential gear and cutting off all current in the electrical installation, all the mechanical power being thus transmitted directly to the driving shaft.

The locking together of all the elements of the differential gear can be effected by any suitable means for example in Fig. 3 with the help of a clutch adapted to lock the planet wheel carrier of the differential gear to the shaft carrying one sun wheel or else with the help of a clutch adapted to lock together the two sun wheels of the differential gear. For example lever 31 may be operated to regulate the clutch 32, 33 on the shaft 6^a, or lever 34 may be operated to regulate the clutch 35, 36 between the sun wheels 7 and 8. In this case, at the same time with the help of the interrupter 37 in the circuit 39 of the excitation dynamo 5; and interrupter 38 in the circuit 13 of connection of the two dynamo-electric machines the current can be cut off in all the electric part of the plant.

In Fig. 3, backward drive has been supposed to be obtained electrically by

reducing the excitation of that one of the two machines 3^a , 3^b the excitation of which is not reduced during the starting of the vehicle in forward direction that is why the gear train 20, 21, 23 and the corresponding devices of Fig. 2 in this figure have been omitted whilst the gear wheel 19 is keyed on the shaft 11.

A power unit of the type above described has numerous possibilities amongst which the following may be mentioned.

1. It is possible to further increase the speed of the vehicle by acting on the rheostat 17 of machine 3^b thereby reducing the separate field excitation, so as to increase its speed V , which determines

an increase in speed $\frac{V}{2}$ of the planet wheel carrier 10^d and a corresponding increase in speed of the vehicle.

2. It is possible to avoid making use of the reversal clutch for operations at reduced speeds. In fact, if the reduction of the excitation of the machine 3^a , on stopping brings about starting in one direction, it is easy to understand that reduction in the excitation of the machine 3^b will bring about starting in the opposite direction. Always it must be noted, that the torque diminishes in this direction with the speed.

It is possible to avoid this inconvenience and often at the same time have a more extensive range of speeds by using more powerful machines, partially dis-excited then stopped. The super-excitation of one or the other of the machines 3^a , 3^b would bring about starting in one direction or the other without reduction of torque.

3. It is possible to increase the power of the dynamo-electric machines up to approximately double the normal power requirements without the total weight of the dynamo-electric exceeding that of the generator and electric motors in power units of the type wherein the power is transmitted from the prime mover entirely electrically. Thus the disposable torque for starting is doubled up

to the speed $\frac{V_m}{2}$ of the planet wheel carriers 10^d and then the torque decreases from the value $2C_m$ to the value C_m from

the speed $\frac{V_m}{2}$ to the speed V_m of the

satellite carrier 10^d. This possibility of variation is very important for increasing the acceleration of the vehicle, the weakness of which is a fault characteristic of Diesel-electric locomotives of current types.

4. In a plant according to the invention the heat engine can be replaced by an alternating or direct current electric motor.

6 In this latter case it is possible at the end of starting to couple in parallel two of the motors or the three motors, and then to obtain an increase of speed by simultaneous alteration of the fields of
10 the three motors.

It is possible thus to equip a trolley vehicle or one fed by a conductor rail, or accumulators. This solution does not lead to a weight of the machine sensibly
15 greater than that necessitated by the equipment of a vehicle of which the variations in speed is obtained by the variation of the field of the motor or motors. It has the advantage of a great simplification of the apparatus and of the almost
20 complete suppression of starting resistances.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A power unit for driving the driving shaft of a vehicle in which one element
30 of a differential is driven mechanically by a prime mover, a second element of the differential is connected to a first dynamo-electric machine electrically connected to a second dynamo-electric machine driven
35 by said prime mover, and the resulting motion of a third element of said differential is transmitted to the driving shaft, characterised by the provision of series field excitation windings for each
40 machine, said windings forming part of the electrical connection between said machines, a separate field excitation winding for each of said machines, a common source of electrical energy connected to said separate field windings,
45 means to adjust the magnitude of current in the separate field winding of said first machine, and means to adjust the magnitude and to determine the direction of
50 current in the separate field winding of said second machine.

2. A power unit as claimed in claim 1 in which is provided means for interrupting current flowing between said
55 machines and in said separate field windings, and means for locking all the ele-

ments of said differential.

3. A power unit as claimed in claim 1 or 2 in which the prime mover is connected to one sun wheel of said differential, said first dynamo-electric machine is
60 connected to a second sun wheel, and the resulting motion of a planetary element is transmitted to the driving shaft of the vehicle.

4. A power unit as claimed in any of claims 1—3 in which said common source
70 of electrical energy comprises an auxiliary generator driven by said prime mover.

5. A power unit as claimed in any of claims 1—3 in which said common source
75 of electrical energy comprises a battery of accumulators.

6. A power unit as claimed in any of claims 1—5 in which said prime mover
80 comprises a heat engine such as a Diesel engine.

7. A power unit as claimed in any of claims 1—5 in which said prime mover
85 comprises an alternating or direct current electric motor.

8. A power unit as claimed in any of claims 1—7 in which a variable resistor
90 comprises the means for adjusting the magnitude of the current in the separate field winding of said first machine.

9. A power unit as claimed in any of claims 1—8 in which a potentiometric
95 rheostat comprises the means for adjusting the magnitude and determining the direction of the current in the separate field winding of said second machine.

10. A power unit as claimed in any of claims 4—9 and in claims 2 and 3 in
100 which said locking means comprises clutch elements adapted to lock said planetary element to a shaft carrying one of said sun wheels.

11. A power unit as claimed in any of claims 4—9 and in claims 2 and 3 in
105 which said locking means comprises clutch elements adapted to lock together shafts carrying said two sun wheels.

12. A power unit as particularly described with reference to Figs. 2 and 3 of
110 the accompanying drawings.

Dated this 10th day of July, 1946.

W. P. THOMPSON & CO.,
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Chartered Patent Agents.

Fig. 2

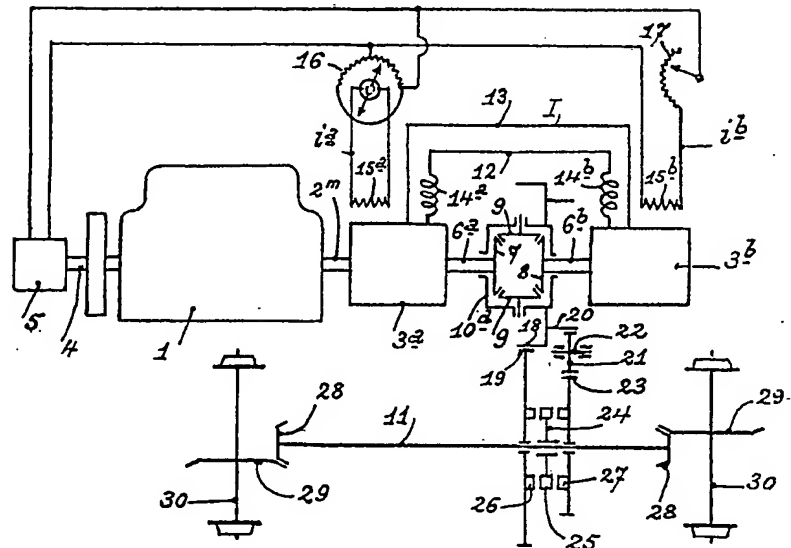
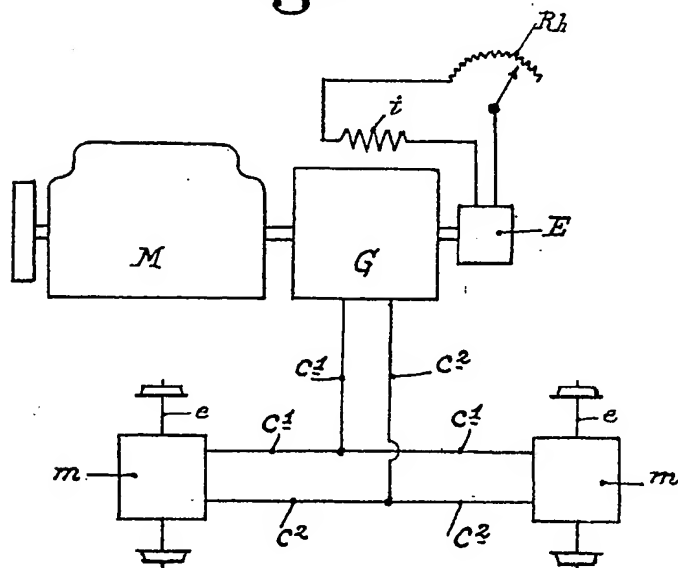


Fig. 1



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 3

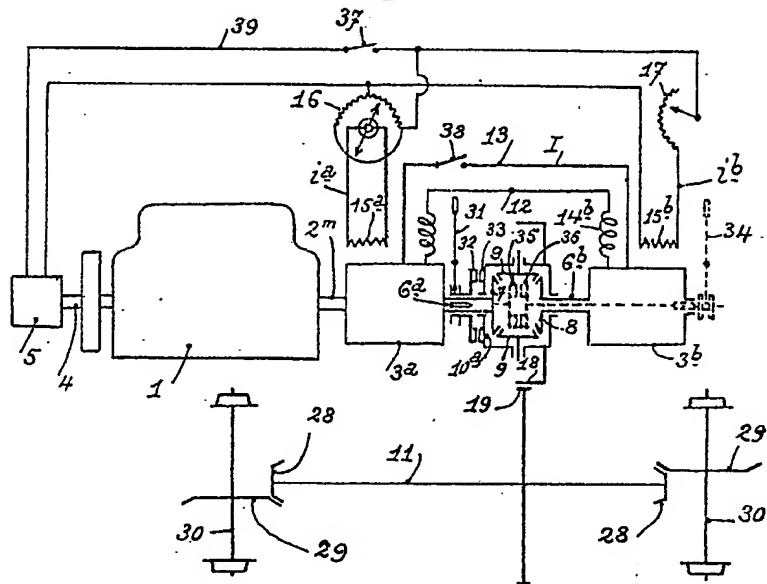


Fig. 2

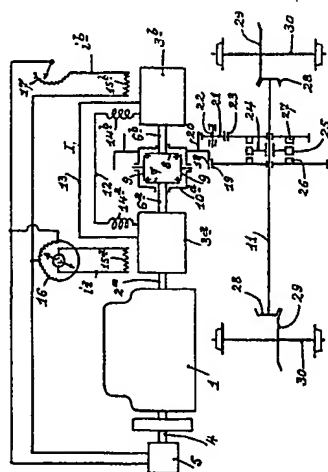


Fig. 1

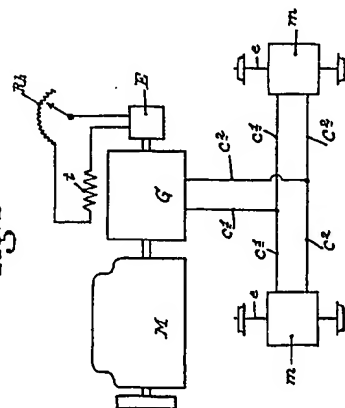
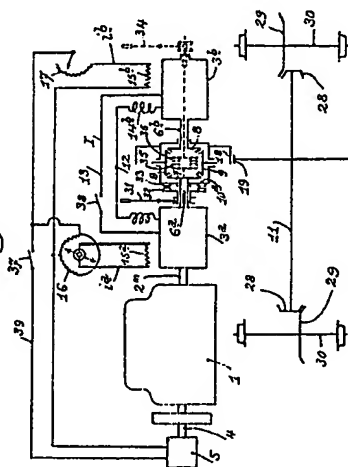


Fig. 3



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